

## **OPTICAL FIBER**

### **CLAIM OF PRIORITY**

This application claims priority to an application entitled "Optical Fiber," filed with  
5 the Korean Intellectual Property Office on January 22, 2003 and assigned Serial No. 2003-  
4311, the contents of which are hereby incorporated by reference.

### **BACKGROUND OF THE INVENTION**

#### **1. Field of the Invention**

10 The present invention relates to an optical fiber, and in particular to an optical fiber  
applicable to both of a Wavelength-Division-Multiplexing (WDM) mode and a Coarse  
Wavelength-Division-Multiplexing (CWDM) mode and, at the same time, meets the  
transmission characteristics employed in the metro networks.

#### **2. Description of the Related Art**

15 An optical fiber comprises a core and a clad, which encloses the core, and the  
refractive index of the core is higher than that the clad. As part of manufacturing process, a  
optical perform prepared and drawn under a heat application to produce a string of optical  
fiber. Some of the known methods for preparing a optical preform includes a MCVD  
20 (Modified Chemical Vapor Deposition) method, VAD (Vapor Axial Deposition) method,  
OVD (outside Vapor Deposition) method, PECVD (Plasma Enhanced Chemical Vapor

Deposition) method, etc. Optical fibers have different characteristics depending on the required transmission lengths and applications. For use in long-haul networks, NZ-DSFs (Non-Zero Dispersion Shifted Fibers) and SMFs (Single Mode Fibers) are mainly used.

Meanwhile, metro networks employ various types of protocols, for example,  
5 Ethernet for the transmission of larger data, such as sound/moving image in the networks of high speed Ethernet, gigabit Ethernet, ESCON (Enterprise System Connection), FICON (Fiber Connection), etc. Metro networks mainly use a bit rate in the range of OC-3 (155 Mbit/sec) to OC-192 (10 Gbit/sec) and must be applicable to currently used transmission systems, which includes the CWDM and Dense WDM (DWDM) schemes. Accordingly, the  
10 metro networks require more elaborate technical requirements when compared to the long-haul transmission networks, thereby causing the cost of network constructions to increase. In order to save costs, various optical fibers are incorporated in a cable, such as a hybrid cable, to meet the demands.

Note that the dispersion values of conventional single mode optical fibers are in  
15 the range of about 17 to 18 ps/nm·km at 1550 nm wavelength, and due to high dispersion values, there is a limit in efforts to narrow the signal intervals. Therefore, in consideration of such dispersion, it has become necessary to interpose DCFs (Dispersion-Compensated Fibers) in order to compensate for the dispersion in the transmission networks.

In this regards, the present invention has been made to solve the above-mentioned  
20 problems occurring in the prior art and provides additional advantages, by providing an improved optical cable that may be realized in a simple, reliable, and inexpensive implementation.

## SUMMARY OF THE INVENTION

The present invention is directed to an optical fiber that has a dispersion value in the range of 13 to 18 ps/nm·km, and a zero-dispersion slope in the range of 0.046 to 0.079 ps/nm<sup>2</sup>·km and in a wavelength region of 1550 nm to 1580 nm.

One aspect of the present invention to provide an optical fiber capable of being applied to both the WDM mode and CWDM mode and meets the transmission requirements employed in the metro networks.

In one embodiment, an optical fiber having a refractive profile is provided and includes a core area extended along a predetermined reference axis, and a cladding area formed around the external circumference of the core area, wherein the radii of the core area and cladding area and the refractive profile are selected such that the optical fiber has the following characteristics: a zero dispersion wavelength in the range of 1300 to 1350 nm; a dispersion value in the range of 13 to 18 ps/nm·km at 1550 nm wavelength; a zero dispersion wavelength in the range of 0.046 to 0.079 ps/nm<sup>2</sup>·km; and, an effective cross-section area of 70 μm<sup>2</sup> or more.

Preferably, the radii of the core area, the cladding area, and the refractive profile are selected so that the optical fiber has a negative dispersion value in the range of -6.5 to -1.3 ps/nm·km at 1270 nm wavelength.

More preferably, the radii of the core area, the cladding area, and the refractive profile are selected so that the optical fiber has a dispersion value in the range of 14.5 to 24.5 ps/nm·km at 1610 nm wavelength.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

5        FIG. 1a is a cross-sectional view of a depressed clad type optical fiber in accordance with a preferred embodiment of the present invention;

FIG. 1b is a graph illustrating the distribution of refractive indexes of the optical fiber shown in FIG. 1a in accordance with the radius of the optical fiber;

10        FIG. 2a is a cross-sectional view of a index matched clad type optical fiber in accordance with another preferred embodiment of the present invention;

FIG. 2b is graph illustrating the distribution of refractive indexes of the optical fiber shown in FIG. 2a in accordance with the radius of the optical fiber; and,

FIG. 3 is a graph illustrating the range of proper dispersion values of the optical fibers manufactured in accordance with the present invention.

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## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, preferred embodiments of the present invention will be described with reference to the accompanying drawings. For the purposes of clarity and simplicity, a detailed description of known functions and configurations incorporated herein will be  
20 omitted as it may make the subject matter of the present invention unclear.

An optical fiber according to the teachings of the present invention may be used in the Coarse Wavelength-Division-Multiplexing (CWDM) scheme and exhibits a geometrical

structure and optical characteristics similar to a single mode fiber (SMF). In addition, the cut-off wavelength and radius of the inventive optical fiber are similar to the SMF, instead of the long-haul DWDM. However, the zero-dispersion wavelength of the inventive optical fiber is in the range of 1300 to 1350 nm and its dispersion value is in the range of 13 to 18 ps/nm·km at 1550 nm wavelength. Accordingly, the inventive optical fiber comprises a lower dispersion value compared to the conventional single mode optical fiber, which has a dispersion value of 18 ps/nm·km at 1550 nm wavelength.

Moreover, the inventive optical fiber has a dispersion slope in the range of 0.046 to 0.079 ps/nm<sup>2</sup>·km at a zero-dispersion wavelength, which is also lower than the dispersion slope of the conventional single mode optical fiber, which is about 0.091 ps/nm<sup>2</sup>·km at a zero-dispersion wavelength. The inventive optical fiber has an effective cross-section area ( $A_{\text{eff}}$ ) of about 70  $\mu\text{m}^2$ , a dispersion value in the range of -6.5 to -1.3 ps/nm·km at 1270 nm wavelength, and a dispersion value in the range of 14.5 to 24.5 ps/nm·km at 1610 nm.

Furthermore, although the dispersion in an optical fiber is mainly influenced by the radius and structure of the optical fiber, the inventive optical fiber has a structure similar to that of the conventional single mode optical fiber. Therefore, it is possible to apply the inventive optical fiber to both the WDM mode and CWDM mode, by selectively tuning the radius and refractive index of the optical fiber. As such, it is also possible to realize an optical fiber that meets optical characteristics employed in the metro networks.

FIG. 1a is a cross-sectional view of a depressed clad type optical fiber in accordance with a preferred embodiment of the present invention, and FIG. 1b is a graph, which shows the distribution of refractive indexes of the optical fiber shown in FIG. 1a in

accordance with the radius of the optical fiber.

Referring to FIG. 1a, an optical fiber 100 in accordance with the embodiment of the present invention includes a core area 110 and a cladding area 120 formed around the external circumference of the core area 110.

5 Referring to FIG. 1b,  $\Delta+$  and  $\Delta-$  indicate the relative refractive indexes, and the of silica (Si), i.e., 1.457 variation indicates the decrement of the refractive index. In the figure of the present embodiment, the core was designed to have refractive index change 0.0005 decrement outwardly. The refractive index of core decreases outwardly from the center of the core. The cladding was designed to have refractive index change. The refractive index  
10 of clad decreases outwardly.

Hereinafter, specific examples of the present invention will be presented for tuning various characteristics of an optical fiber, by setting the diameter of the optical fiber constant while varying the refractive index of the optical fiber. I The radius a of the core is 4.47  $\mu\text{m}$  and the radius b of the cladding is 10.12  $\mu\text{m}$ .

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#### Example 1

In this example, the relative refractive index  $\Delta+$  and the variation of the core equal 0.0030 and 0.0005, respectively, and the refractive index  $\Delta-$  and variation of the cladding are  $-0.0010/ -0.0005$ , respectively. As stated earlier, the relative refractive index shown in  
20 the drawing is the refractive index of silica (Si), 1.457. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 1.

Table 1

$\Delta+/\text{variation}$	$\Delta-/\text{variation}$	Zero-dispersion wavelength (nm)	Zero-dispersion slope	Effective area ( $A_{\text{eff}}$ ) ( $\mu\text{m}^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0030/ 0.0005	-0.0010/ -0.0005	1327.5	0.0764	89.1935	-4.7573	13.0394 - 14.3010	15.4396

Example 2

- 5 In this example, the relative refractive index  $\Delta+$  and the variation of the core equal 0.0035 and 0.0005, respectively, and the refractive index  $\Delta-$  and the variation of the cladding are  $-0.0015$  and  $-0.0005$ , respectively. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 2.

10 Table 2

$\Delta+/\text{variation}$	$\Delta-/\text{variation}$	Zero-dispersion wavelength (nm)	Zero-dispersion slope	Effective area ( $A_{\text{eff}}$ ) ( $\mu\text{m}^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0035/ 0.0005	-0.0015/ -0.0005	1311.0	0.0785	72.0319	-3.5579	14.6093 - 15.8856	17.0202

Example 3

- In this example, the relative refractive index  $\Delta+$  and the variation of the core equal 15 0.0035 and 0.0005, respectively, and the refractive index  $\Delta-$  and the variation of the

cladding equal  $-0.0013$  and  $-0.0005$ , respectively. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 3.

Table 3

$\Delta+/\text{variation}$	$\Delta-/\text{variation}$	Zero-dispersion wavelength (nm)	Zero-dispersion slope	Effective Area ( $A_{\text{eff}}$ ) ( $\mu\text{m}^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0035/ 0.0005	-0.0013/ -0.0005	1313.0	0.0789	73.7900	-3.7272	14.7217 – 16.0818	17.3212

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Example 4

In this example, the relative refractive index  $\Delta+$  and the variation of the core equal 0.0037 and 0.002, respectively, and the refractive index  $\Delta-$  and the variation of the cladding equal  $-0.0013$  and  $-0.0005$ , respectively. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 4.

Table 4

$\Delta+/\text{variation}$	$\Delta-/\text{variation}$	Zero-dispersion wavelength (nm)	Zero-dispersion slope	Effective area ( $A_{\text{eff}}$ ) ( $\mu\text{m}^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0037/ 0.002	-0.0013/ -0.0005	1312.0	0.0769	75.5870	-3.6000	13.5123 – 14.7265	15.7916

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FIG. 2a is a cross-sectional view of a index matched clad type optical fiber in accordance with another preferred embodiment of the present invention, and FIG. 2b is graph showing the distribution of the refractive indexes of the optical fiber shown in FIG. 2a in accordance with the radius of the optical fiber.

5 Referring to FIG. 2a, an optical an optical fiber 200 in accordance with the embodiment comprises a core area 110 which extends along a predetermined reference axis and a cladding area 120 formed on the external circumference of the core area 110. The cladding area 120 includes a ring type cladding area 130 which has a higher refractive index than the remaining area.

10 Referring to FIG. 2b,  $\Delta+$  and  $\Delta-$  indicate the relative refractive indexes of silica (Si), as in FIG. 1b. Hereinafter, specific examples of the present invention will be presented for tuning various characteristics of an optical fiber, by setting the diameter of the optical fiber constant while varying the refractive indexes of the optical fiber. The radius a of the core is set to  $4.47\ \mu\text{m}$ , the radius b of the cladding is set to  $10.12\ \mu\text{m}$ , and the internal radius  
15 c and external radius d of the ring type cladding area are set to  $7.12\ \mu\text{m}$  and  $8.12\ \mu\text{m}$ , respectively.

#### Example 5

In this example, the relative refractive index  $\Delta+$  and the variation of the core equal  
20  $0.0030$  and  $0.0005$ , respectively, and the refractive index  $\Delta-$  and the variation of the cladding equal  $-0.0010/ -0.0005$ , respectively. As described above, the relative refractive index is referenced to the refractive index of silica. In the ring type cladding area,  $\Delta 1+$  and

variation equal 0.000 and 0.0, respectively and  $\Delta-$  and variation equal 0.001 and 0.0, respectively. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 5.

5 Table 5

$\Delta+ /$ variation	$\Delta- /$ variation	$\Delta 1+ /$ variation	$\Delta 1- /$ variation	Zero- dispersion wavelength (nm)	Zero- dispersion slope	Effective area ( $A_{eff}$ ) ( $\mu m^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0030/ 0.0005	-0.0010 / -0.0005	0.0000/ 0.0000	-0.001/ 0.0000	1330	0.0755	84.3746	-4.9866	13.0197 - 14.3321	15.5311

### Example 6

In this example, the relative refractive index  $\Delta+$  and the variation of the core equal 0.0030 and 0.0005, respectively, and the refractive index  $\Delta-$  and the variation of the cladding equal -0.0010 and -0.0005, respectively. In the ring type cladding area,  $\Delta 1+$  and variation equal 0.010 and 0.0000, respectively, and  $\Delta-$  and variation equal -0.001 and 0.0000, respectively. The transmission characteristics of an optical fiber designed in this manner are indicated in Table 5.

Table 6

$\Delta + /$ variation	$\Delta - /$ variation	$\Delta 1 + /$ variation	$\Delta 1 - /$ variation	Zero- dispersion wavelength (nm)	Zero- dispersion variation	Effective area ( $A_{eff}$ ) ( $\mu m^2$ )	1270nm dispersion	1550 – 1580nm band dispersion	1610 nm dispersion
0.0030/ 0.0005	-0.0010 / -0.0005	0010/ 0.0000	-0.001/ 0.0000	1336.6	0.0711	88.0893	-5.5493	13.2957 - 14.8195	16.2664

FIG. 3 is a graph which shows a range of proper dispersion values for the optical fibers in accordance with the present invention. As shown, it can be appreciated that a proper dispersion value is ranged between a dispersion value (I) of a standard SMF and a dispersion value (II) of a nonzero dispersion optical fiber(NZDSF) over substantially all bands (D, E, S, C, L, U).

An optical fiber (for CWDM) in accordance with the present invention is intended for a longer distance transmission when compared to an SMF but not so long as DWM, so that it may be used for an intermediate range transmission. Note that the cut-off wavelength and radius of the optical fiber of the present invention are similar to those of an SMF. Therefore, the dispersion slope of the optical fiber according to the teachings of the present invention is somewhat higher than the dispersion slope of NZDSF because it is not used for the long-haul transmission.

The inventive optical fiber has dispersion values in the range of 13 to 18 ps/nm·km in the 1550 to 1580 wavelength band, which are lower than those of the existing standard SMF, so that it is possible to reduce optical signal spreading caused by the dispersion over a

broad bandwidth compared with SMF.

In addition, the inventive optical fiber is also advantageous in that because it has a large effective area, it is possible to greatly reduce the non-linear phenomena compared with NZDSF which may be produced in WDM transmission. As such, the present  
5 invention can reduce the costs for constructing communication networks.

Accordingly, the present invention is capable of being applied to both the WDM mode and CWDM mode and meets the transmission characteristics employed in metro networks. Therefore, it is possible to substitute the inventive optical fiber for the existing optical fibers. Hence one type of an optical fiber meets various demands according to the  
10 teachings of the present invention, it is possible to further reduce the costs for constructing metro networks. A metro network needs a fiber which has a large bandwidth and long-length transmission. The inventive optical fiber has a larger bandwidth than that of NZDSF(using CWDM) and it can realize long-length transmission compared with SMF.

While the invention has been shown and described with reference to certain  
15 preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.